Hello:

This message is an invitation to participate in a NASA sponsored workshop on the NRC Decadal Survey mission called CLARREO (see the NRC report). The workshop is planned for 2.5 days on July 17-19 in the Washington, DC area.

The NRC briefing to NASA on the Decadal Survey stated that the missions are notional and the costs 'representative,' so that further clarification of the details and requirements of the mission and approach are needed. The CLARREO concept is to provide benchmark spectral and broadband radiance capability in orbit that can serve both as its own climate data record and to calibrate less accurate space-borne instruments with wavelengths in the solar reflected and thermal infrared emission portions of the spectrum. CLARREO is one of the first missions listed in the Decadal Survey, hence the need for an early workshop. You are being invited to attend based on your science and/or engineering expertise in satellite-based climate observations and their calibration.

Workshop Goals

a) *Specify CLARREO requirements to allow its use as an in-orbit calibration system for other satellite radiometers and spectrometers used for climate observations.*

These requirements would necessarily include absolute accuracy, SI unit traceability, stability per decade, spatial resolution, spectral resolution, spectral coverage, linearity, spacecraft and instrument pointing capability and accuracy, time interval between climate accuracy calibrations of other instruments, time/space/angle requirements for calibration of other instruments, dynamic range required for calibration of other instruments against the CLARREO benchmark in order to determine linearity of other instruments, mission overlap requirements until absolute accuracy is demonstrated in orbit sufficient to allow short gaps to occur, length of gaps allowable in the CLARREO record (i.e. time to launch following failure), allowable risk for a CLARREO record gap, instrument and spacecraft design life (3/5/7 yr designs), orbits of other instruments that CLARREO should be capable of calibrating (e.g. all sun-synchronous low earth orbit, all precessing low earth orbit, all geostationary). In the context of these requirements, are one, two, or three CLARREO satellite orbits required to handle calibration of other radiometers?

b) *Specify CLARREO requirements to serve as a benchmark time series of spectral and broadband radiance to directly observe climate change*.

This capability is called out for in the NRC Decadal Survey executive summary of CLARREO, but not in the chapter on Climate Variability. Define if this requirement is for clear-sky regions and/or all-sky conditions, and define requirements relative to current IPCC AR4 high-priority uncertainties such as aerosol radiative forcing and cloud feedback. Define the same requirements as for item (a) above, including calibration, space/time/angle/spectral sampling, instrument, orbit requirements, allowable gap risks and gap time intervals. Determine if the system in (a) used to calibrate spectrometers like CrIS and IASI on the 3 operational weather satellites at 930/130/530 local times can meet

the benchmark spectral radiance requirement. In the context of these requirements, are one, two, or three CLARREO orbits needed to handle gaps and diurnal cycle sampling?

c) *Specify CLARREO requirements to monitor Total Solar Irradiance and Spectral Solar Irradiance.*

The CLARREO mission calls for continuity of Total and Spectral Solar Irradiance observations (TSIS). Confirm the accuracy and sampling requirements. Since the concepts for solar reflectance calibration in a) rely on the use of active cavity calibration, determine if the strategies used to achieve items a) and b) can also serve as the basis of Total and Spectral Solar Irradiance observations. This is a potential mission synergy and cost savings.

d) Specify CLARREO requirements for GPS temperature and humidity profiles.

The Decadal Survey chapter on climate variability called for more accurate GPS frequency standards in orbit for temperature/humidity profiling using GPS signals. This GPS frequency calibration was not included in CLARREO. Confirm the removal of this requirement from the final CLARREO mission requirements.

e) Determine the technological readiness to conduct the CLARREO mission requirements.

Examine the ability to realize from the current state of the art engineering, technology, and metrology perspective the capability for long term SI traceable standards in orbit, primarily using high accuracy blackbody sources in the infrared part of the spectrum and high accuracy cavity detectors in the solar wavelength part of the spectrum. Use would also be made of the sun and moon as sources. Since CLARREO is one of the early missions, technology development should be very limited for this mission.

f) The workshop will not consider the CLARREO recommendation for flight of the broadband CERES instruments on NPP and NPOESS. This is a separate activity that NASA-NOAA-NPOESS are pursuing as part of the response to the Nunn-McCurdy removal of climate instruments from NPOESS. Since the CERES instruments or their follow-ons require flight with global imagers such as MODIS or VIIRS, they would not be flying on the same spacecraft as CLARREO, and can be considered separately.

Summary

The essence of the CLARREO concept is "*Climate Calibration First."* It is intended to extend SI traceable climate accuracy calibration to both solar and infrared radiance measurements by NPOESS and other earth remote sensing systems. These same systems often struggle to reach the accuracy required of unambiguous climate change signals. CLARREO would be able to calibrate narrowband filter radiometers, spectrometers, interferometers, and broadband instruments. Examples would include satellite instrument observations of ocean color, vegetation, cloud, aerosol, snow, ice, SST, atmospheric

temperature, humidity, and broadband radiances used for radiation budget. The CLARREO calibration instruments are intended to be small, light, and much less expensive than instruments designed to observe the earth 'wall-to-wall' such as MODIS, VIIRS, SeaWiFS, AIRS, CrIS, or IASI. CLARREO will not, however, extend into the passive microwave wavelengths. The nominal total spectral range covered by CLARREO is roughly 0.2 to 50 micron.

We hope you can attend and contribute to the definition of this key climate mission. The recent Nunn-McCurdy elimination of climate instruments on NPOESS has driven home the severe difficulties still faced by climate observations. CLARREO represents a vision from the Decadal Survey to make a wide range of satellite observations more useful for climate change studies. This workshop is intended to flesh out that vision using a broad base of earth science and engineering expertise. While this is expected to be a small focused workshop, it is intended to be an open workshop. If you know of individuals who would be particularly relevant to the workshop, please send their contact information and a brief summary of their area of expertise to me at *donald.anderson-1@nasa.gov.*

NASA Earth Science funds remain limited, and requirements should be viewed from a cost/benefit perspective. Escalation of CLARREO requirements that increase cost significantly is not an option.

This workshop will be used to determine the next steps appropriate to achieving CLARREO. Such next steps could include further workshops, studies needed to clarify key requirements, international collaboration, and needed technology development.

Logistics

Please contact me (email optimal) as soon as possible regarding both your attendance and recommended additions to the mailing list for attendance. The expected format of the workshop will be plenary session talks for most of day 1, working group sessions for day 2, and a final half-day of plenary working group reports and final discussion. The output of the workshop should include a set of recommended requirements, a summary of any open issues, and suggested next steps. The agenda for the workshop will be sent out in mid-June. If you have a presentation that you think would be critical to the success of the workshop, please send me a title, presenter name, authors, abstract, and amount of time needed. It is unlikely we will be able to accommodate all such requests, but the intent is to assure capturing the current understanding of the broader science and engineering communities. We will allocate space for posters to offer the opportunity for added detail and coffee break discussion.

There will be ample time for full discussion in the working group sessions, but note that we expect this workshop to run late each day and hope to have a venue that will allow working lunches and ready access to either on site or local restaurants for dinner.

Finally, I expect this email list (clarreo@listserv.gsfc.nasa.gov), and its additions in the coming weeks, to be utilized for pre-workshop discussion. We will provide summaries in

advance of two internal NASA studies at JPL and LaRC. I am also setting up open web access to this information and pertinent information/papers ahead of the meeting. This may be more useful than trying to send attachments with the mailing list as there are server limitations for attachments. Lara Clemence will be our point of contact for posting information to the public web page for CLARREO (http://map.nasa.gov/clarreo.html) or making changes to this mailing list. Because we value your input and want to make sure you are included on important information, we ask that you please confirm with Lara that you received this email. Her email address is: lara.b.clemence@nasa.gov and she can be reached by phone at: (301) 286-4097. Please note in any correspondence to Lara, 'CLARREO Workshop.'

We look forward to your contributions at the workshop.

Sincerely,

Don Anderson
Modeling, Analysis and Prediction
Earth Sciences Division
Science Mission Directorate
NASA HQ